Accelerated Breeding for Resistance to Fusarium Head Blight

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Research Questions

Complete resistance to Fusarium Head Blight (FHB) is unavailable, yet genetic variability for resistance is well documented. Steady progress toward increasing resistance levels has been demonstrated by breeding programs through the implementation of largely repeatable FHB screening procedures. Breeding programs must sustain efforts to simultaneously select resistant materials with desirable agronomic characteristics. The objective of this project is to use traditional plant breeding and selection techniques to develop hard red spring wheat germplasm and cultivars that possess agronomic characteristics worthy of release in addition to acceptable levels of FHB resistance.

Results

Entries retained in the advanced yield trial (AYT) are generally at least moderately resistant to FHB. Those that do not perform adequately are discarded after the first year of AYT observation. 2018 AYT results are presented in the appendix. Thirty-four experimental breeding lines were tested along with fourteen check cultivars during the 2018 growing season. Of the thirty-four experimental lines, twenty seven had FHB disease index (DIS) values that were less than the test average. Among these entries, seventeen produced more grain than average. Among these seventeen, test weight of thirteen entries was higher than average, and protein content of four ('Forefront', SD4708, SD4763, and SD4765) were also greater than average. Although protein content of SD4539 was slightly lower than average, it will be considered for release in late fall 2018. The same is true with SD4625, which may be released in 2019. SD4708 may also be released in fall 2019 or 2020.

Application and Use

With the progression of time, increases in FHB resistance levels should help to prevent devastating loses to growers caused by severe FHB outbreaks.

Materials and Methods

Focused efforts to increase resistance began within this program after the 1993 FHB epidemic in the spring wheat production region. Both mist-irrigated greenhouse and field screening nurseries were established and disease evaluation methods were developed. Breeding materials are evaluated for FHB resistance using three generations per year: two in the greenhouse and one in the field. We have the capacity to screen as many as 4,500 individual hills in the greenhouse. We also have 4 acres in the field under mist-irrigation. Both the field and greenhouse nurseries are inoculated with grain spawn (corn that is infested with the causal fungus) and spore suspensions. Mist-irrigation is used to provide a favorable environment for infection. Approximately 25 percent of the experimental populations possess *Fhb1* as a source of resistance. Most of what remains are crosses with various "field resistant" advanced breeding lines. Experimental materials are advanced through the program in the following fashion;

Year 1	Field	Space planted F_2 populations
Year 1	Fall greenhouse	$F_{2:3}$ hills
Year 1	Spring greenhouse	$F_{3:4}$ hills
Year 2	Field	$F_{4:5}$ progeny rows
Year 2	Off-season Nursery	$F_{5:6}$ progeny rows
Year 3	Field	$F_{5:7}$ Yield Trials (1 replication, 2 locations)
Year 4	Field	$F_{5:8}$ Yield Trials (2 replications, 5 locations)
Year 5	Field	Advanced Yield Trials (3 reps, 8 locations)

F_2 populations are planted in the field and individual plants are selected. These are advanced to the fall greenhouse where seed from each plant is sown as individual $F_{2:3}$ hills and evaluated for FHB resistance. Four plants from each of the top 25% of the hills are advanced to the spring greenhouse. They are sown as individual $F_{3:4}$ hills and evaluated for FHB resistance. Those with FHB resistance nearly equal to or better than 'Brick' are advanced to the mist-irrigated field nursery as $F_{4:5}$ progeny rows. They are evaluated again for resistance and general agronomic performance. Plants are selected within the superior rows and sent to New Zealand as $F_{5:6}$ progeny rows for seed increase. A portion of seed from each selected plant is also grown in the fall greenhouse to confirm its resistance. If the FHB resistance of an $F_{5:6}$ line is confirmed, then the respective progeny row is harvested in New Zealand. In the following South Dakota field season, the selected lines are tested in a two replication, multi-location yield trial. Those that have agronomic performance and yield similar to current cultivars are included in more advanced, multi-location, replicated yield trials the following year. In year 5, lines advanced through this portion of the program are included in the AYT along with entries from the traditional portion of the program. Performance data with respect to DIS, along with agronomic potential from the 2018 AYT are presented in Table 1 of the appendix.

Economic Benefit to a Typical 500 Acre Wheat Enterprise

The presence of FHB inoculum within fields and favorable weather conditions are just two factors that heavily influence whether this disease becomes problematic. Immediate economic benefits are therefore difficult to assess. When conditions become favorable for disease development, however, cultivars with elevated FHB resistance levels can help to reduce potentially serious grower losses. »

» Appendix:

Table 1. South Dakota State University advanced yield trial spring wheat entries ranked according to FHB disease index values (lowest to highest – collected at Brookings) presented along with agronomic data obtained from three replication trials conducted at seven test environments in 2018.

ENTRY	DIS INDEX	YIELD (BU/AC)	TW (LB/BU)	PROTEIN (%)	HEADING (D > 6/1)	HEIGHT (INCHES)
BRICK	16.4	38.2	60.9	16.6	15.5	28.7
FOREFRONT	17	41.7	60.5	16.6	17.5	30.9
FALLER	19.3	45.8	59.7	15.2	22.9	29.7
FOCUS	19.3	40.4	60.8	17.1	15.4	29.1
SD4752	19.4	39.9	60.6	16.8	20.7	30.1
SD4625	19.9	44.2	60.5	16	19.2	28.5
SD4721	19.9	38.5	59.4	16.7	18.8	26.9
SURPASS	20.3	41.1	59	16.4	17.6	28.6
BOOST	20.4	41.8	59.6	16.7	22.5	29.1
SD4765	20.4	41.6	60.1	16.7	18.8	28.8
SD4539	20.5	43.1	60	16.4	21.1	31.7
SD4740	20.5	37.6	60.1	16.5	18.2	28.6
SD4787	20.7	38.6	59	17.5	16.6	27.9
SD4708	21.5	42.7	60.6	16.6	19.3	30
SD4771	21.6	39.6	57.5	16.6	17.1	24.4
SD4745	21.7	39.4	60.4	17.7	19.9	30
SD4763	21.8	41.1	59.8	16.7	21	29
SD4748	22.1	36.1	58.6	17	17	28.4
SD4756	22.3	42.1	60.7	16.4	16.7	28.5
SD4772	22.6	42.4	59.6	16.3	17.8	26.8
SD4792	22.6	42.5	59.6	18.1	24.2	29.3
PREVAIL	22.7	44.4	59.8	15.8	19.1	28.8
SD4711	22.8	41	60.5	16.4	15.8	29.2
SD4719	23	45.9	59.7	15.7	21.3	30.4
SD4773	23.3	45.9	59.9	16.4	22.4	28.6
SD4764	23.5	40.4	59.8	16.5	17.2	27.9
SD4706	23.6	43	59.8	16	16.8	30
ADVANCE	23.8	43.2	61.1	15.6	20.4	27.2
LCS-TRIGGER	23.8	48.5	60.2	14.3	24.4	28.7
SD4796	24.3	36.9	60.4	17.1	17.1	26.3
SD4770	24.5	38.5	58.7	16.2	17.8	25.8
TRAVERSE	24.8	43.3	57.6	15.5	19.4	30.4
SD4775	25	46.7	59.3	15.9	24.2	29.7
SELECT	25.1	37.4	60.8	16.4	17.3	29.2
STEELE-ND	25.4	39.3	60.1	16.6	19.9	29
SD4794	25.6	40	59.6	17.9	19.7	27.7
SD4789	26	37.9	60.1	16.5	17	26.9

Table 1 *continued*

ENTRY	DIS INDEX	YIELD (BU/AC)	TW (LB/BU)	PROTEIN (%)	HEADING (D > 6/1)	HEIGHT (INCHES)
SD4720	26.1	39.1	58.9	17.9	19.8	30.1
SD4762	27	37.5	58.3	17.2	18.2	27.5
BRIGGS	27.6	37.3	59.3	16.8	17.9	28.2
SD4758	27.6	39.7	60.1	15.9	19	28.3
OXEN	27.8	40.3	58.5	16.3	18.5	26.9
SD4746	28.4	39.1	61.2	17	18.8	28.1
SD4818	28.9	39.6	57.8	17.6	19	28.5
SD4791	29.2	38.2	58.2	17.7	20.8	29.4
SD4816	30.6	43.8	60.2	16	22.6	28.8
SD4707	30.8	36.8	57.6	17.3	19	28.4
SD4814	32.8	44.4	59.3	16.1	21.4	29
MEAN	23.63	40.97	59.66	16.57	19.22	28.63
LSD (0.05)	5.46	1.57	0.25	1.88	0.43	0.53
cv	15.31	7.15	1.59	4.44	11.91	4.71

Publications

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